Astrophysics Practice Questions – Markscheme

1. B

2. B

3. A

4. A

5. C

6. D

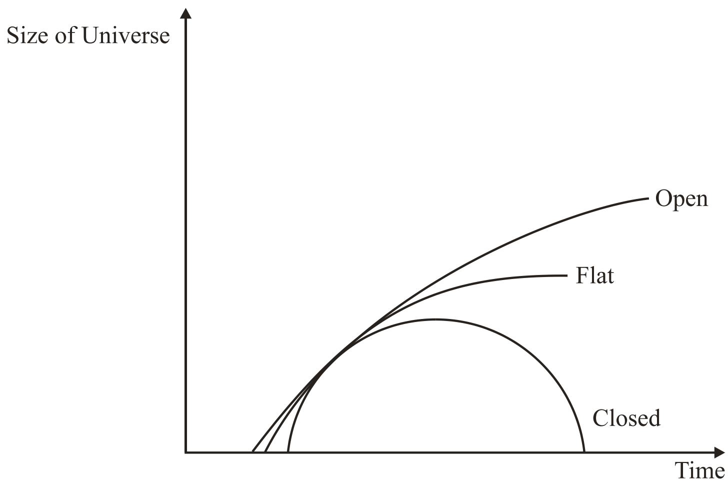
7. C

8. B

9. C

10. C

11. (a)



3 max

(b) 3 max

Type of Universe	*Relation between ρ and ρ_0*
Open	$\rho < \rho_0$
Flat	$\rho = \rho_0$
Closed	$\rho > \rho_0$

[6]

12. (a) (i) luminosity is the total power radiated by a star / source; 1

(ii) apparent brightness is the power from a star received by an observer on Earth per unit area of the observer's instrument of observation; 1

Accept $b = \dfrac{L}{4\pi d^2}$ *if L and d are defined.*

(b) the surface area / size of the star changes periodically (due to interactions of matter and radiation in the stellar atmosphere); 1

(c) (i) at two days the radius is larger / point A;
because then the luminosity is higher and so the area is larger; 2

(ii) *Award **[1]** for each relevant and appropriate comment to the process of using Cepheid variables up to **[3 max]** eg*

Cepheid variables show a relationship between period and luminosity;
hence measuring the period gives the luminosity and hence the distance (through $b = \dfrac{L}{4\pi d^2}$);
distances to galaxies are then measured if the Cepheid can be ascertained to be within a specific galaxy; 3

(d) (i) $b = \dfrac{L}{4\pi d^2} \Rightarrow 1.25 \times 10^{-10} = \dfrac{7.2 \times 10^{29}}{4\pi d^2}$;

$d = \sqrt{\dfrac{7.2 \times 10^{29}}{4\pi \times 1.25 \times 10^{-10}}}$;

$d = 2.14(\pm 0.2) \times 10^{19}$ m; 3

(ii) *Award **[1]** for each relevant and appropriate comment to the phrase "standard candles" up to **[2 max]** eg*

the phrase *standard candle* means having a source (of light) with known luminosity;

measuring the period of a Cepheid allows its luminosity to be estimated / other stars in the same galaxy can be compared to this known luminosity; 2

[13]

13. (a) cosmic background radiation is microwave radiation;
"filling" the universe / from all directions; 2

Award other relevant and appropriate comments eg "at a temperature of about 3K or left over from the Big Bang".

(b) the Big Bang predicts an expanding universe that had a very high temperature at the beginning; during the expansion the universe is cooling down and the temperature of the radiation should fall to its present low value, (which is precisely what the cosmic background radiation measures); 2
or
Big Bang producing initially very short wavelength photons / em radiation;
as the universe expands, the wavelengths become redshifted / longer (to reach current value); 2

(c) the redshift in the light observed from distant galaxies (indicating that they are moving away from each other) / the helium abundance in the universe which is about 25% and is consistent with a hot beginning of the universe; 1

(d) the student is wrong; space is created as the universe expands / there is no outside to the universe; 2

[7]

14. (a) apparent magnitude is a measure of (comparative) brightness as seen from Earth (with 1 being brightest and 6 being dimmest);
absolute magnitude is the apparent magnitude that the star would have if it were a fixed distance from the Earth of 10 parsecs; 2

(b) yes plus reason; 1

(c) (i) distance away = $\frac{3.39 \times 10^{17}}{9.46 \times 10^{15}}$ = 35.8 ly = 11.0 pc; 1

(ii) since this is less than 100 pc;
the star is close enough for stellar parallax; 2

(iii) *Award* ***[1]*** *each relevant piece of experimental description up to* ***[4 max]****.*
eg position of star compared with other star positions;
at different times of the year;
the maximum angular variation from the mean p is recorded;

the distance (in parsecs) can be calculated using geometry $d = \frac{1}{p}$ if p is in arcseconds;

example:
spectroscopic parallax: light from star analysed (relative amplitudes of the absorption spectrum lines);
to give indication of stellar class;
HR diagram used to estimate the luminosity;
distance away calculated from apparent brightness;

Cepheid variables: these stars' brightness vary over time;
the time period of the variation is related to their luminosity;
thus measurements of the time period of one star can be used to calculate its luminosity;
its distance away is calculated from maximum apparent brightness; 4 max

(d) spectral type / K / *OWTTE*;
thus at low end of temperature scale: OBAFGKM / Sun is G / *OWTTE*; 2

(e) (i) correct substitution into $L = \sigma A T^4$;
to get A = $\frac{3.8 \times 10^{28}}{(5.67 \times 10^{-8} \times 4000^4)}$ $= 2.62 \times 10^{21}$ m^2; 2

(ii) use of $4\pi r^2 = 2.62 \times 10^{21}$ m^2;
to get $r = 1.44 \times 10^{10}$ m (= 0.10 AU); 2

(iii) use of $\lambda_{max} = \frac{2.90 \times 10^{-3}}{4000}$;
= 725 nm ≈ 730 nm; 2

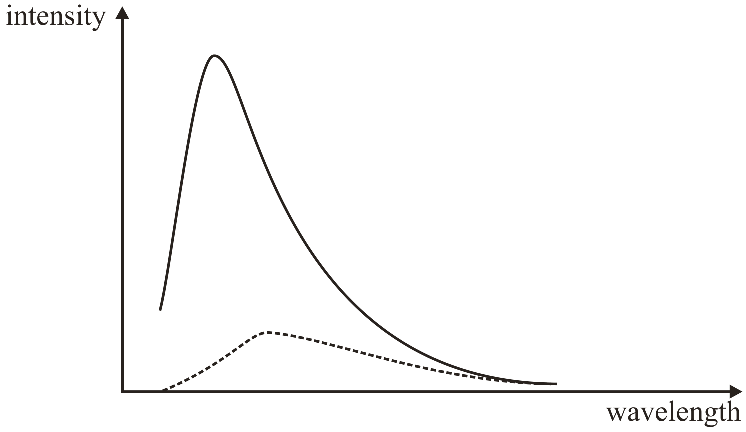
(f) red giant;
since it's big and it's red / *OWTTE*; 2

[20]

15. (a) the radiation emitted by a perfect emitter / perfect absorber / cavity / emits radiation in accordance with the Planck law; 1

(b) wavelength / λ; 1

(c)



lower intensities;
maximum shifted to the longer wavelength; 2

(d) $T = \dfrac{2.90 \times 10^{-3}}{\lambda} = \dfrac{2.90 \times 10^{-3}}{9.70 \times 10^{-7}} = 3000\ K$; 1

[5]

16. (a) (i) spectral class; 1

Accept colour sequence.

(ii) absolute magnitude; 1

(b) 4

Star	***Type of star***
A	Main sequence;
B	Super Red Giant;
C	White Dwarf;
D	Main sequence;

(c) B more luminous than A;
and has lower temperature than A;
so from the Stefan-Boltzmann law;
B has greater area (radius); 3 max

(d) use of $L = 4\pi b d^2$;
from the H-R diagram $L_B = 10^6\ L_{Sun}$;
therefore $\dfrac{L_B}{L_{sun}} = 10^6 = \dfrac{7.0 \times 10^{-8} \times d_B^2}{1.4 \times 10^3}$;
to give $d_B = 1.4 \times 10^8\ AU$ ($\approx$ 700 pc); 4

(e) at this distance the parallax angle is too small to be measured accurately;
OWTTE; 1 max

Do not accept "it's too far away"

[14]